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IX

GEOLOGY OF A PORTION OF THE MCKITTRICK
DISTRICT, A TYPICAL EXAMPLE OF THE WEST
SIDE SAN JOAQUIN VALLEY OIL FIELDS,
AND A CORRELATION OF THE OIL
SANDS OF THE WEST SIDE FIELDS*

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INTRODUCTION

That portion of the great oil belt of California lying along the western border of the San Joaquin Valley and the adjacent foothills, beginning north of McKittrick, and extending southward through Midway and Sunset, is commonly known as the West Side Oil Fields.

The geology of this area was first mapped by Dr. Ralph Arnold¹, who, while following in the main the divisions worked out at Coalinga, did not differentiate the upper Miocene and Pliocene formations, but grouped them together as a unit under the name of the McKittrick Formation.

During the past four years members of the geological force of the Southern Pacific Company² have done some careful and detailed mapping in this area and the interpretation of this mapping, particularly in the vicinity of the southern part of the McKittrick Oil Field, has given a clearer knowledge of the deposits than previously existed, and permits the making of a clearer separation, and a closer correlation with the corresponding formations of the Coalinga region. At the same time a close study of records and logs and of the materials and fossils taken from the oil wells of these West Side Fields enables us to draw some interesting and important conclusions regarding the stratigraphy and age of the various oil zones encountered in them.

This paper is presented with a two-fold object:

1. Of differentiating the upper Miocene and Pliocene deposits of the West Side Fields, and correlating them with their northern equivalents in the Coalinga Field;
2. Of showing the age and correlation of the oil sands themselves of the West Side Fields.

ACKNOWLEDGMENTS

The writer is indebted to many operators and oil men who have kindly given logs, information, fossils, and other materials and data since the Midway-Sunset fields first began

¹ Bull. U. S. G. S. 406.

² Note: This paper was nearly completed three years ago when the author was in the employ of the Southern Pacific Co.

rapid developments in 1908. More particularly is he indebted to Mr. F. M. Anderson, with whom he was associated under Prof. E. T. Dumble of the Southern Pacific Co. for several years. Thanks also are due to Messrs. F. H. Kay, B. L. Cunningham, J. A. Taff, R. W. Pack, E. G. Gaylord, F. B. Tough, and Prof. E. T. Dumble for assistance, information and criticism. A free use has been made of all publications and maps bearing on this area; the latest and most comprehensive of which are Bull. U. S. G. S. No. 406 by R. Arnold and H. R. Johnson and the topographic sheet of the McKittrick Quadrangle. The latter enlarged to a one-inch scale was found to be very useful. The reader is referred to Bulletin 406, page 15, for a condensed bibliography.

I. UPPER MIOCENE AND PLIOCENE DEPOSITS OF THE WEST SIDE FIELDS

LOCATION

The general area under discussion in this paper extends south and southeast from the town of McKittrick, Kern County, California, to the southern end of the developed Midway-Sunset field. The accompanying map, enlarged from a portion of the U. S. G. S. topographic sheet of the McKittrick quadrangle, shows the area to which particular reference is made. This is known as the South-End McKittrick Field and was chosen because in this particular locality there are exposed typical fossiliferous sections of the Upper Miocene, Lower Pliocene (Etchegoin) and Pliocene,—fresh water beds usually referred to as the Tulare. This area occupies the southwestern portion of T. 30 S., R. 22 E., M. D. B. & M. The town of McKittrick is located on a branch of the Southern Pacific R. R. in the northern part of the area.

TOPOGRAPHY

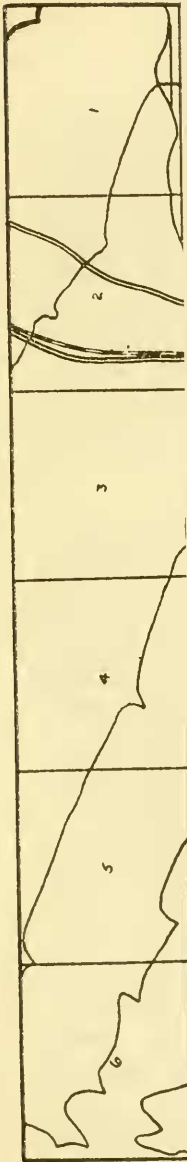
The topography of the South-End McKittrick area is similar to that of the lower foothills of the Temblor Range, being the combined result of structural and erosional agencies. Extending southeastward from the McKittrick Oil Field is a

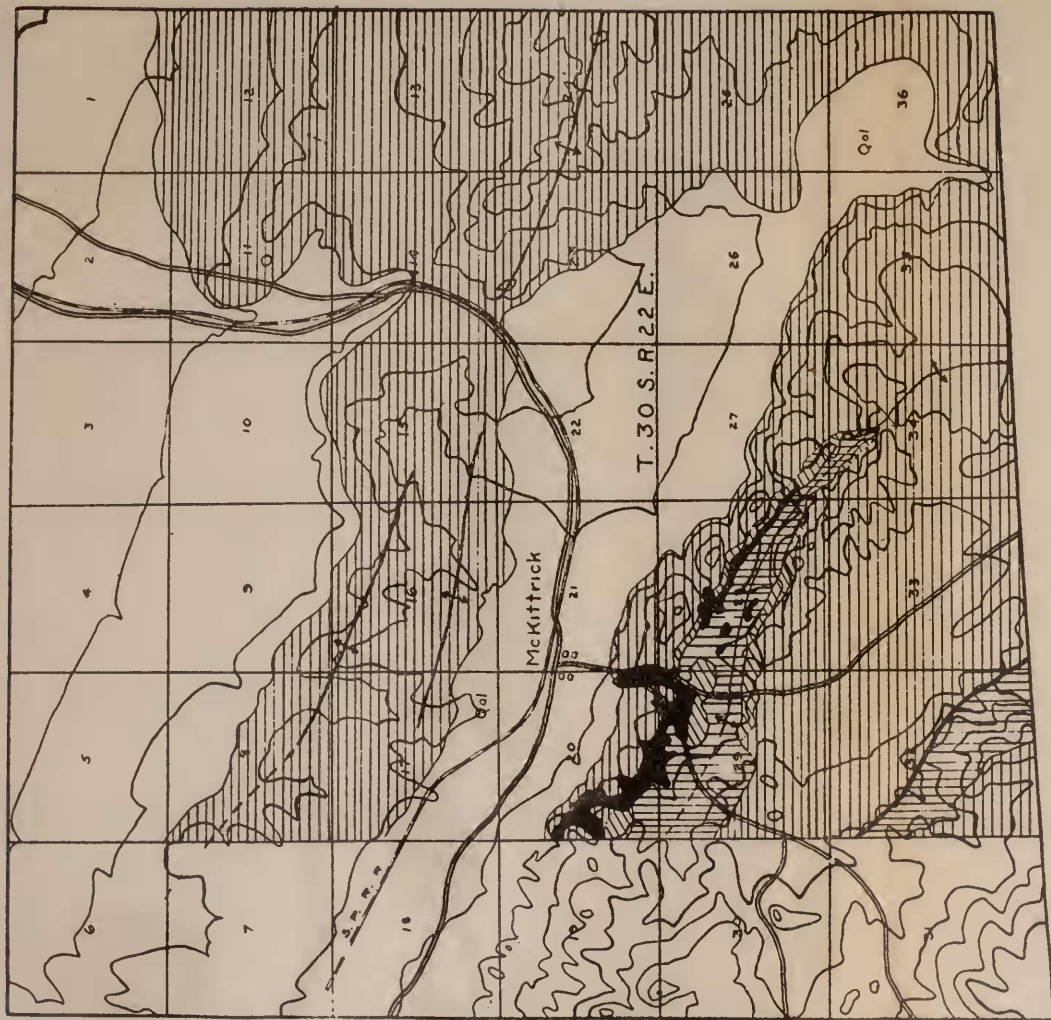
low range or ridge divided in part by a narrow valley. This ridge has a course of S. 60 degrees E. and in a general way has its continuation in the Buena Vista Hills. Its highest points rise to elevations in the neighborhood of fifteen hundred feet above sea level and a thousand feet above the floor of the San Joaquin Valley. The narrow valley, referred to above, has an elevation of from 1300 to 1350 feet and is the result of the erosion of much shattered shales and sands along the apex of a sharp and faulted anticline. Here, as well as along the whole belt of the West Side Oil Fields, the dissection of old and recent valley floors, stream flood-plains, terraces, and fans is indicative of a general uplift of the region. Eastward through the hills three steep-sided gulches lead out from the small valley, in which are located some sulphur springs, sometimes called Steamboat Springs. Along the sides of these gulches there are more or less well preserved stream terraces and flood-plains marking the once higher levels of the streams. At one locality in Sec. 28 horizontal and cross bedded oil stained detritus and brea form a prominent terrace feature. Similar oil-stained deposits are found throughout the entire length of the gulches and have frequently been mistaken for live oil sands in places.

GEOLOGIC FORMATIONS

General Statements: Three and possibly four formations besides the stream and valley alluviums are recognized within this small area and afford a comprehensive example of the formational relationships that exist in the McKittrick, Midway and Sunset Fields. On both sides of a sharply folded and locally faulted anticline there is exposed below the alluviums:

- (1) Pliocene, Tulare fossiliferous, fresh water beds from 1250 to 1800 feet in thickness;
- (2) Lower Pliocene, Etchegoin fossiliferous marine sands, clays and marls 200 feet, or more;
- (3) Light colored organic shales with sandstone and calcareous layers and lenses. These shales may be either Santa Margarita or Monterey or both. Their posi-





LEGEND

- | | | | |
|---|-----------|---|-----------------|
|  | Alluvium. |  | Santa Margarita |
|  | Tulare |  | Brea |
|  | Etchegain | | |

Scale . 1 inch = 1 mile

tion indicates the former. Observations and detailed mapping both to the north and to the south of this area show quite clearly that both of these formations contain organic shales, and are separated by local and probably by regional unconformities.

There are well marked unconformities in the South-End McKittrick area between the Tulare and Etchegoin, and between the latter and the underlying shale series. Identical conditions are found in nearly every locality in the West Side Fields where the overlapping Tulare has not completely covered the Etchegoin. Good examples of this unconformable condition are to be seen in the Gold Hills northwest of McKittrick, and in the vicinity of Fellows and on Muddy and Los Lobos creeks in the San Emigdio Ranch. Poorer exposures are found southeast of Fellows and just south of old Sunset.

SUPERFICIAL DEPOSITS

The only superficial deposits worthy of note are some of the remnants of former stream flood-plains. In this particular area, many of these contain oil sands or materials impregnated with oil which in some places largely consist of impure asphaltum. The latter beds are usually spoken of as brea beds. They are formed along the sides of the gulches below the oil and tar springs. Where sandy they are distinctly cross-bedded, but when composed largely of asphaltum with minor amounts of angular shale and sand fragments they show very poor bedding. A few bones of extinct animals have been found buried in these beds, among which are some classed by Prof. J. C. Merriam as belonging to a species of dog, or wolf. Some horse and elephant bones have also been reported from this locality. These are of Quaternary age. In the more recent deposits are occasional bones of small birds and rodents, but they are far less numerous than in the Rancho La Brea deposits of Los Angeles. On an old stream terrace in the workings of the abandoned asphaltum mines, some mammalian remains considerably older than those above referred to were found and are now in the possession of Prof. J. C. Merriam at the University of California.

These stream terraces, well developed in some localities, display a considerable range in elevation and are the results of stream action and of oscillations which operated through long periods of time, extending back into Pleistocene and possibly late Pliocene time.

TULARE

Excepting the superficial deposits, the uppermost formation exposed in this area is a fresh water terrane which may be correlated with the Tulare. The Tulare was named by Mr. F. M. Anderson in his paper entitled "A Stratigraphic Study of the Mount Diablo Range in California,"³ but was previously described by W. L. Watts.⁴

These beds at McKittrick, Midway and Sunset are described by Dr. Ralph Arnold as a portion of the McKittrick series which he acknowledges may be in part Tulare.

In the South-End McKittrick field the Tulare is composed of from 1250 to 1800 feet of loosely consolidated sands, clays, marls and conglomerates or fragmental shale beds exposed on both sides of an anticlinal fold and separated in part by the small valley previously mentioned. The whole mass is light colored, varying from yellowish gray to drab and is easily eroded, forming steep sided gulches.

In the upper division there are considerable quantities of sand and fragmental shale beds with minor strata of clay. The fragmental shale beds are in a way unique. They are made up in some instances wholly of small angular and sub-angular shale fragments derived from the underlying shale formations. All the facies of shale common to the Santa Margarita and Monterey of the adjacent areas are found mingled with comparatively little sand as if, in Tulare time, these beds were formed by a rapid denudation of the nearby shale areas.

The lower part of the Tulare is, in a general way, made up of finer sediments than the upper, containing considerable clay and marl. A little conglomerate, of which the boulders and pebbles are mostly well rounded old crystallines and hard sandstones, is found near the base. Some of the clay is gyps-

³ Proc. Calif. Acad. Sci. Geol., Vol. 2, 1905, No. 12.

⁴ Calif. State Mining Bur., No. 3, 1894.

iferous and fragments of pure crystalline gypsum are commonly seen on the surface. Near the base are several strata of oil sands and in a sandy shale associated with the oil-impregnated sands are fresh water Tulare fossils. One of the best fossil localities is near the mouth of a small tunnel which was driven for asphaltum, in early days, in the northeast part of the N. E. $\frac{1}{4}$ Sec. 34, T. 32 S., R. 22 E. The fossils occur in a stratum three to four feet wide, which is overlain by clays and underlain by an oil sand which strikes N. 65 deg. W. and dips 70 deg. to the northeast. South of this locality on the east side of a small gully is an oil sand containing several fresh water species. From these two localities there was recognized such forms as

Anodonta kettlemanensis (Arnold).
Anodonta andersoni (Arnold).
Ammicola andersoni (Arnold).
Carinifex marshalli (Arnold).
Physa humerosa (Gould).

Several sections were made across the Tulare, the following being a typical one, beginning at the top:

Soft yellow and gray sands, strike N 62° W, dip 65° NE	150 ft.
Fragmental shale bed	66 "
Yellow sand	40 "
Gray sand, shale fragments at base.....	125 "
Clay	20 "
Gray sand	150 "
Clay and gray sand	90 "
Sandy clay	60 "
Fragmental shale	15 "
Clay	20 "
Gray sand	100 "
Yellow sand and clay, fresh water fossil horizon..	90 "
Thin bedded shale and sand, streaks of oil sand..	85 "
Clay and sand and few pebbles, fresh water fossil horizon	60 "
Oil sand containing some pebbles.....	10 "
Clay	45 "
Oil sand	20 "
Clay and sand	60 "
Total	1150 "

This section is figured at right angles to the strike in one of the gulches in Sec. 27.

Another section was made across these beds a mile to the south which has a similar stratigraphic sequence but is nearly

400 feet thicker. The greater thickness is due to a better and more complete section of upper Tulare beds being exposed. A third section was made across the hills to the west of the little valley in the S. W. $\frac{1}{4}$ of Sec. 27. In this section the sequence of beds again correspond very closely and show a thickness of from 1250 to 1300 feet.

Stratigraphy: The Tulare, as heretofore indicated, occupies the outside of a southeastward plunging anticlinal fold. It forms the outer rim of the hills to the south of McKittrick, striking N. 60° to 65° W. and dipping to the northeast at from 50° to 80° . In section 35 it swings south and westward around the end of the anticline, thence along the summit of the hills to the northwest through the S. W. $\frac{1}{4}$ of Sec. 27. On the southwest side of the fold the beds dip from 30° to 42° to the southwestward.

There is a small local anticlinal fold crossing the gulch in Sec. 28, but it can not be traced for any distance on either side of the gulch. Also along the contact with the Etchegoin, notably in S. W. $\frac{1}{4}$ of Sec. 27 local faulting has contorted and displaced parts of the basal member of the Tulare.

The basal member of the Tulare rests unconformably upon the underlying sands of the Etchegoin. In this particular area there are four proofs of unconformity, (1) difference of strike and dip, (2) marked overlap within short distances, of the Tulare upon the Etchegoin, Santa Margarita and Monterey, (3) an abrupt change from fresh water to marine conditions, (4) the Etchegoin beds of this locality, the Lost Hills, the Midway fields and perhaps Sunset are not the Upper Etchegoin of the Kettleman region but the lower Etchegoin of the Coalinga district. This fact deserves to be emphasized and the various lists of fossils available are such as belong to and characteristic of the lower, though not the lowest Etchegoin.

Along the whole front of the slopes of the West Side Oil fields from North McKittrick to San Emigdio Ranch, wherever there are good exposures of the Tulare with the underlying beds, there is a discordance in dip and strike which varies from a few degrees to as much as twenty degrees. This differs in degree only from the condition in the Kettleman Hills where angular unconformity is less visible and is repre-

sented by an overlapping of the Tulare upon the underlying Etchegoin sands.

The lower dipping Tulare in the South-End McKittrick field is seen within short distances to rest successively upon Etchegoin sands and Santa Margarita shales. In some localities it cuts very abruptly across the edges of the former. In fact it is only occasionally that any Etchegoin is to be found exposed, for the Tulare usually extends far across the edges of the older shale series.

The faunal break is even more apparent as is well exhibited near the north line of the N. W. $\frac{1}{4}$ Sec. 35. Here the *Anodonta* and *Carinifex* bearing sands are found dipping at 60° within 200 to 300 feet of nearly perpendicular beds containing such forms as *Pecten eldridgei*, *Pseudocardium gabbi*, *Echinarachnius gibbsi*, *Nassa californica*, etc.

RELATIONS TO PETROLEUM

Throughout the whole extent of the West Side oil fields some oil sands are found associated with the Tulare. The oil sands are near the base and do not extend far up into the series. It is an oil that has migrated into the Tulare sands from the underlying beds and these sands are rarely productive of oil in economic quantities in the fields south of the Belridge. In several wells in the Maricopa flats fresh water fossils have been found associated with tar sands above the productive oil measures which in numerous localities contain marine Etchegoin forms.

In the Belridge field some of the oil and gas at least seems to be derived directly from the sands within or at the base of the Tulare. Many of the wells in the central part of the field on Secs. 33 and 34 of Township 28-21 have thrown out large quantities of sand saturated with oil and containing shells and fragments of fresh water species such as

Anodonta species.
Sphaerium.
Ammicola, etc.

Among the wells producing oil from these fresh water sands are wells Nos. 3 and 4 of the General Petroleum Co., Sec. 3, Township 29-21 and several neighboring wells of the Belridge Oil Co.

In the South End McKittrick area the basal 100 feet of the Tulare contains similar oil sands associated with fresh water fossils. Several shallow wells have been drilled into these sands, but production has been small and the oil heavy. This oil unquestionably came up along the stratification planes of the underlying beds and coming in contact with the porous sands of the lower Tulare, migrated along them.

ETCHEGOIN: (LOWER PLIOCENE)

No definite separation has previously been made of the Etchegoin in the McKittrick, Midway, and Sunset fields. Several writers have suggested that it existed but no one has definitely segregated its small areas scattered along the lower foothills. It is without doubt the most important oil producing formation of the West Side fields, and for that reason it should be clearly distinguished from all others.

It is exposed as small areas of sands, oil sands, clays, light marls, and marly shales along the lower foothills and is usually overlapped at both ends by the Tulare. Only a few clear cut contacts with the underlying shales can be found.

The recognition of sediments of the Etchegoin in the South McKittrick area was due to the discovery of a prolific bed of fossils made of *Pecten eldridgei*, *Echinarachnius gibbsi*, and *Ostrca*, species along the McKittrick Sunset Road. This bed is traceable along its strike for a mile or more. It is best exposed to the east of the county road in the N. E. $\frac{1}{4}$ of Sec. 28. The lower part of the Etchegoin at this locality is made up of well-rounded hard quartzose and granitic pebbles along with which are strata of gray and yellow firm to hard sands with occasional layers of porous white, marly shales. The latter might easily be mistaken for organic shales. The line of pebbles at the base is persistent and can be followed with a few breaks around the south end of this area and westward again for several miles along the front of the McKittrick oil field.

Within the particular area treated in this report the Etchegoin forms a very narrow belt, mostly of sandstone strata from the N. E. $\frac{1}{4}$ Sec. 29 diagonally across Sec. 28 and the S. W. $\frac{1}{4}$ Sec. 27. Around the point of the anticline in Sec.

34 are one or two small patches of sand questionably referred to as the Etchegoin. Across the S. 1/2 of Sec. 28 yellow and gray Etchegoin sands strike N. 74° W. and extend into Sec. 29, where they are covered by the overlapping Tulare beds. Fossils of the same species that characterize the Lower Etchegoin of the Coalinga district are found in several localities in this area. The best collections were made from a hard gray sandstone on the southeast slope of a knoll in the S. W. 1/4 of Sec. 27. At this locality among the species recognized are

- | | |
|------------------------|----------------------|
| Echinarachnius gibbsi. | Ostrea atwoodii. |
| Pecten eldridgei. | Macoma nasuta (?) |
| Pecten coalingensis. | Macoma inquinata. |
| Pecten crassicardo. | Neverita recluziana. |
| Pseudocardium gabbi. | Nassa californica. |
| Cardita californica. | Lunatia lewisii. |
| Arca trilineata. | |

On the western flank of the anticline in Sec. 28 and 29 Etchegoin fossils are also found. The bed of abundant, well preserved *Pecten eldridgei* has already been mentioned. In this bed occur many broken shells of a small oyster. South-east of the *Pecten eldridgei* beds in the same stratigraphic position in a firm yellowish sand several specimens of *Echinarachnius gibbsi* were collected.

Near the fossil locality in the S. W. 1/4 Sec. 27, sections were made across the Etchegoin which, beginning at the top, contain

Gray sand, conglomerate and pebbles.....	30 ft.
Oil sand, conglomerate and pebbles.....	25 "
Oil sand	50 "
Gray sand and oil stained shaly beds	20 "
Hard gray sand and marine fossils.....	80 "
Gray sand in part oil sand shale below.....	25 "
Total	230 "

The above section is the composite result of several sections on the east side of the fold. In one locality boring mollusks indicating strand line conditions were found in fine grained, indurated sand on top of the shale. A loosened fragment showed the holes extending from a coarse hard sand into a firm sandy shale.

The stratigraphic sequence of the Etchegoin near the Shamrock wells just to the northwest of the area mapped is similar

to the above section and of about the same thickness. It is as follows:

Conglomerate and coarse sand beneath soft Tulare strata.
 Oil sands.
 Clay and marly shale.
 Oil sand and conglomerate.
 Hard cemented coarse gray sand with fragmental shells.
 Granite pebbles and coarse sand.
 Light shaly oil stained beds.
 Gray sand.

Beneath the gray sand is a great thickness of organic shales.

STRATIGRAPHY

Like the Tulare, the Etchegoin forms both flanks of an eroded anticline in the South-End McKittrick area, and is in general more steeply inclined than the Tulare with some small variances in strike. Along the south flank it is partly covered by wash from the overlapping Tulare and on the north flank is locally faulted. A good example of this faulting, which is very complex, is found near the south line of Sec. 27 and in the northern part of Sec. 34. This faulting is probably the southward continuation of the faulted zone which in the McKittrick field has thrown a part of the shale series (Santa Margarita or Monterey) across the top of the oil bearing zone, from which, in one well at least, Etchegoin fossils have been found.

RELATION TO PETROLEUM

Directly overlying the great masses of organic shales the sands of the Etchegoin have acted as storage reservoirs for the oil. As is shown in the sections, the oil sands lie scattered throughout the whole of the exposed Etchegoin, being closely associated with fossils of that age. This condition is true of most of the West Side fields as will be mentioned later. In the South-End McKittrick area the surface exposures showing the relation of the oil to the Etchegoin are good, but unfortunately little drilling has been done in that immediate neighborhood. A few wells, principally in Sec. 34, formerly known as the Belgian wells, have produced some oil. Nearly everywhere in this district that Etchegoin strata are exposed, oil sand or oil seepages are found associated with them. The

porous Etchegoin sands separated by occasional shales or marls and overlain by clays of the Tulare naturally form excellent reservoirs for the accumulation of oil.

SHALE SERIES: SANTA MARGARITA (?)

Beneath the Etchegoin and occupying the apex of the anticline is a series of organic shales. As previously stated the shales may belong either to the Santa Margarita or to the Monterey or to both. Both of these formations can be recognized along the Mt. Diablo Range and both of them contain organic shales, but from the general stratigraphic sequence, the beds underlying the Etchegoin around McKittrick are tentatively classed as Santa Margarita. The Santa Margarita consists of a series of crushed and sharply folded silicious and organic shales which in this area occupy a small depression through the central part of Sec. 28 and across the S. W. $\frac{1}{4}$ Sec. 27 into the N. W. $\frac{1}{4}$ of 34. Westward through Section 29 the area widens out and joins the mass of organic shales which forms the mass of the Temblor Range west of McKittrick and Sunset. As only a small portion of the series is exposed in this area no attempt was made to determine its thickness, and the shales are furthermore so broken and so uniform in quality that no statement of lithological sequence is possible. Westward from McKittrick these shales are a mile or more in thickness and within the area described there are several hundred feet of uniformly bedded white shales exposed. Interstratified with these shales are numerous thin beds or hard calcareous layers. These limy beds are more abundant in the lower part of the shale series than in the upper.

RELATIONS TO PETROLEUM

In the upper part of the Santa Margarita the shales are frequently found to be very white on the surface, but when broken the fresh exposures are a dull chocolate color due to the presence of bituminous matter. This is usually found to be very dry, but in one or two instances oil was found in small vugs or holes in chunks of a very hard silicious shale. The shale is frequently very diatomaceous, in which casts of

diatoms can be seen with a hand lens, but as a rule it is not of that extremely light porous variety which is found around Santa Maria and Lompoc. Excepting in occasional shattered zones, notably in the sandy shale or sandstone lenses relatively near the top, there are no productive oil measures in the definitely recognized Santa Margarita, but according to a current theory of the origin of the California oils, it is from this and the underlying series of shales that the oil of the West Side fields originated.

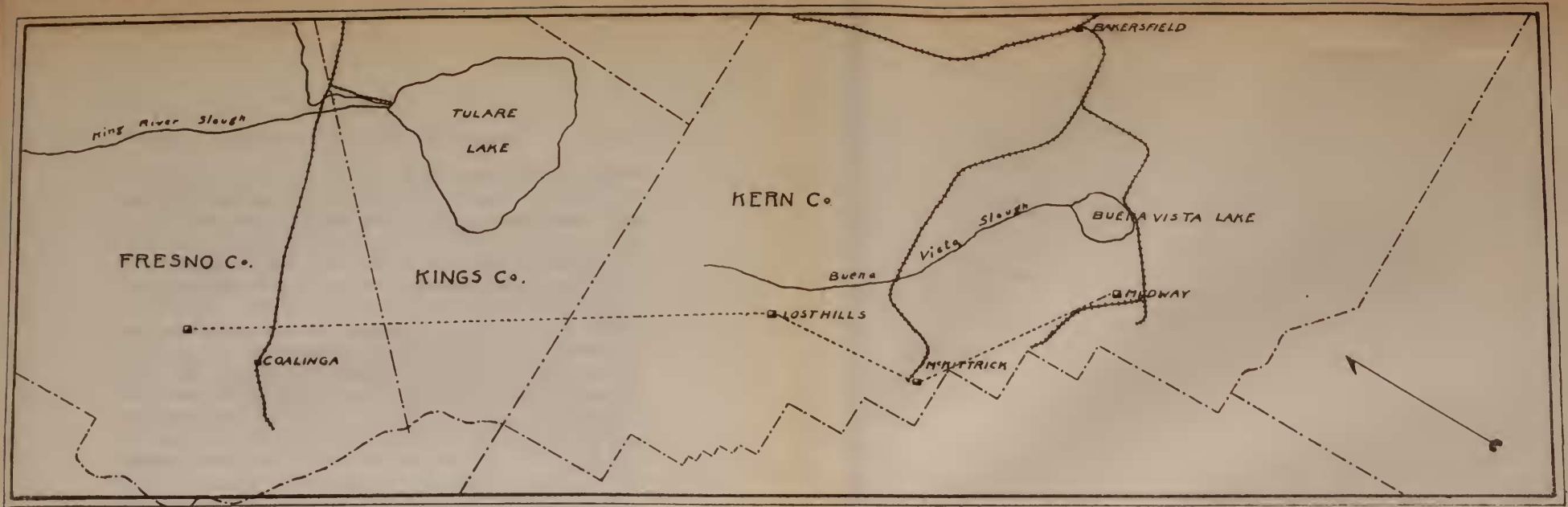
In the South-End McKittrick area there are no indications of the presence of productive oil zones in the Santa Margarita, but oil stained silicious shales are abundantly developed. Farther to the south, however, in the vicinity of Fellows, the Santa Margarita contains sandy shales and sandstone lenses, some of which are coarse and full of granite boulders. These sand and boulder lenses in a few localities contain small amounts of dry oil stains.

We have, therefore, in this particular area, clearly defined representatives of the Tulare, Etchegoin and Santa Margarita formations, and by careful mapping we have been able to show the outcrops of these different formations in the West Side fields. The great importance of their separate mapping is seen in connection with their relation to the oil deposits which are now the sources of such great material wealth in this region.

II. AGE AND STRATIGRAPHY OF THE OIL HORIZONS OF THE WEST SIDE FIELDS

A general conception of age and stratigraphic relationships of the oil sands of the West Side fields can be gotten from a glance at the accompanying idealized section. This section was compiled from surface outcrops and from well data. In order to make the information more complete the Coalinga section was also included. The section is intended to show the relative average thickness of the formations in the various fields, their stratigraphic relationships and the position of the known oil sands.

It is to be noted that with the exception of the Coalinga field the greatest production comes from the Etchegoin (Lower Pliocene) sands.



COALINGA

LOST HILLS MCKITTRICK MIDWAY and TEJON

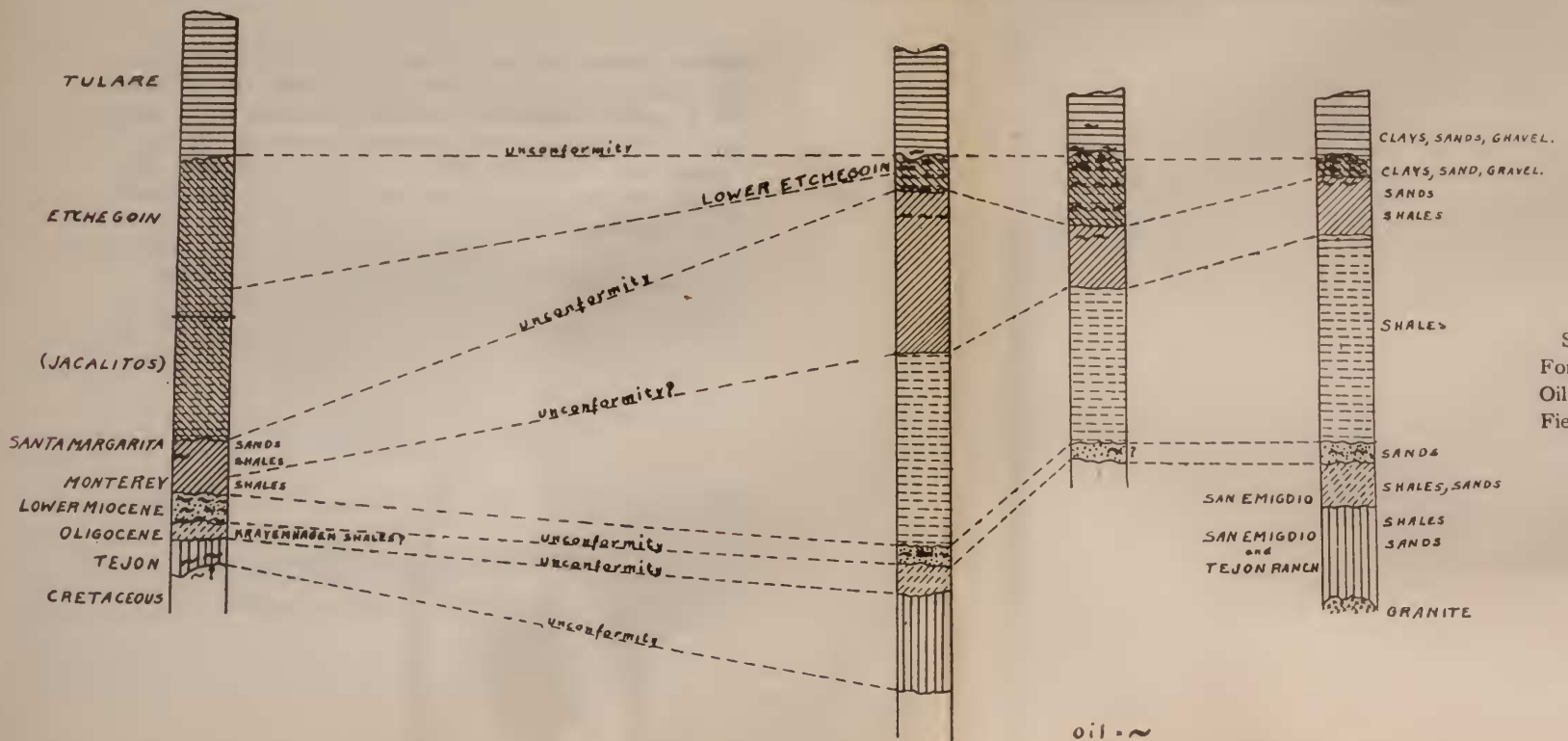


DIAGRAM
 Showing Relative Thickness of Formations and the Position of the Oil Sands in the West Side Oil Fields, California.